PART III. ASSOCIATED INVESTIGATIONS

The following studies use data collected during regular programs as described in the Study Agreement. These investigations, while not cited in the Study Agreement, provide answers to problems realized after our ordinary program started, or augment the ordinary programs.

THE KING SALMON FISHERY

During the course of year-round creel census for resident fish, data was collected on the fishery for king salmon. Because of work commitments on other projects the intensity of the census varied from year to year. Therefore, the total number of anglers interviewed during any one year does not necessarily represent the angling intensity or the distribution of anglers throughout the river that year. Indeed, too little information was collected to make estimates during 1969.

The same areas of the river used in other creel census were used here with king salmon (page 64 this report). Angler success varied widely between years and between areas within years. (Catch rates were highest in 1972 at 0.053 fish/angler hour and lowest during 1970 when 0.018 fish/angler hour were recorded (Table 74).

DISTRIBTUION OF ADULT KING SALMON IN THE FEATHER RIVER

The abundance of salmon spawning in any particular area of the river is a function of the salmon population level in the entire river that year and the suitability of that particular area for successful spawning.

Of particular interest was the distribution of spawning salmon in the low flow river section. There are ten spawning riffles in this river area (Figure 87). During the past four years from 16,800 to 25,500 salmon have spawned here (Table 1). Fish distribution on these ten riffles, as determined by carcass recovery, is not random. Over 80 percent of the fish use the upper five riffles (Table 75). It is no coincidence that this population density split is centered at the waste effluent discharge from Dry Creek (Figure 87).

The distribution of recovered carcasses for the high flow river sections is also presented. The distribution in the reach from Thermalito River Outlet to Gridley Bridge is in Table 76; from Gridley Bridge to Honcut Creek is in Table 77. These are given here in anticipation of need for a future check on fish distribution. A sewage discharge of significant magnitude will begin immediately below the Thermalito River Outlet sometime in 1975.

THE EFFECT OF FLOW REDUCTION DURING INCUBATION OF SALMON EGGS

The purpose of waterflow criteria during the October-November period and then through March is to protect spawning salmon and their resultant eggs, larvae, and fry. The October 15 to November 30 period is the index to flow reduction limits during the remainder of the spawning-nursery period. Only once during our studies were the lower limits of the existing criteria approached.

In early November 1972, the Feather River flow was decreased, in stages, from 3,000 cfs towards 1,700 cfs. This dropped the water surface about seven inches. We recognized serious problems on the spawning areas and arranged to have the flow reduction stopped at 2,100 cfs.

At 2,100 cfs we observed the tops of numerous redds exposed to the air. Also, some large pools were formed that created traps. These cut-off pools would prevent emerging salmon from the redds in the pool areas from migrating downstream.

We examined both exposed and non-exposed redds to evaluate the effect of this flow reduction upon egg survival. Only 78.4 percent of the eggs and/or larvae were alive in the exposed redds we sampled while 97.3 percent were alive from the inundated redds (Table 78).

At this time during the spawning season we would expect about one half the spawning to be completed. We estimated that about ten percent of the redds constructed during this first half of the season were exposed. Therefore, approximately five percent of the spawning of this year class of salmon were affected.

Discussion

Adult salmon are known to build their nests or redds in water as shallow as three to six inches (Burner, 1951). If a decrease in river depth occurs before egg deposition in the redd, the adult salmon will abandon their chosen spawning site and move to deeper water. If all other sites are "taken" then these displaced salmon will be forced to spawn in less desirable areas or upon the spawn in already completed redds. The effect of such crowding has already been demonstrated (see Part II, page 40).

Decreasing river depth during hatching and nursery periods may cause mortality in several other ways. First, exposed redds, though still "wet", may allow extremely cold temperatures to kill or inhibit embryo growth (Silliman, 1950). Second, hatched fry are not very mobile until 80-90 days after eggs are deposited and may not be able to seek lower waterfilled areas in the redd as decreased river depth occurs. Third, some mortality will occur in only periodically exposed king salmon redds as observed by Meekin (1965).

In the present situation serious effects of dewatering redds can be prevented if river depth decreases are kept to less than four inches. Over most of our riffle areas, such a decrease would be equivalent to about 500 cfs (Appendix III-15).

Conclusion

The flow schedule in the agreement between Department of Water Resources and Fish and Game should be modified to lessen the negative effects of flow reduction upon eggs and sac-fry. The flow schedule should read:

During Period October 1 through November 15

Mean Flow (cfs)*	Minimum Fish Flow (cfs)
2,500 - 3,000	500 cfs < mean flow*
3,000 - 3,500	" " " "
> 3,500	3,000

*Average release to Feather River for one hour period.

PREDATION OF YEARLING KING SALMON UPON WILD KING SALMON FRY

During the 1971-72 king salmon fry outmigration study we noticed obvious predation occurring at the release sites for our marked fish. Even though we switched release locations daily upstream and down, from one side of the river to the other, wherever we planted fish we could see predators darting, turning, and flashing as they took both wild and our marked fry. In late January we attempted to catch some of these predators with rod and reel. A twenty-minute fishing effort period was established, or ten fish, whichever came first. Fork length and stomach contents of all predators taken was recorded.

From January 21 to February 15 we sampled 157 predators; all yearling king salmon (Table 79). These yearlings had 209 king salmon fry in their stomachs, or an average of 1.3 fry per yearling. King salmon fry were found in 58 percent of the predators stomachs, insect remains 75.2 percent, and only five percent were empty.

Feather River Hatchery released 531,620 yearling king salmon into the Feather River in the Vance Avenue area during the 1971-72 spawning season. Approximately 369,000 yearlings were planted in November 1971, 103,000 fish during December, no yearlings in Jaunary 1972, and almost 60,000 fish were planted during February (Table 80). These fish apparently did not migrate downstream immediately but stayed in the upper river area.

The observed predation had a significant effect upon numbers of fry migrating out of the Feather River in 1972. This outmigration and survey was similar in many ways to the previous year study. During both years we sampled for 42 days and approximately the same number of marked fry were released (Table 81). Each of these years would be described as a "dry" year even though flows were not identical (Figure 88). Egg survival was good during both seasons (79.7 vs. 62.3 percent in 1970-71). The number of female salmon in each run was different (21,711 vs. 27,000 females in 1970-71) and of course the number of outmigration were dissimilar (24.5 million vs. 41 million fry in 1970-71).

Because conditions were so alike, and we fished nets at the same locations, we expected about the same number of marked fry returns in 1972 as we captured in 1971. However, only 119 marked fish were recaptured in 1972 while 314 marks were recovered during the previous year survey (Table 81).

Again, because conditions and survey efforts were so alike we expected an outmigration of 32 million fry $\left(\frac{27{,}000 \text{ females, } 1971}{21{,}711 \text{ females, } 1972} \times \frac{40.1 \text{ million fry, } 1971}{X \text{ million fry, } 1972}\right)$ in 1972 instead of 24.5 million. We attribute this difference of 7.5 million fish to yearling predation. To eliminate this many fry, each of the 531,000 yearlings would have to have eaten 14 fry during the outmigration season. This is not an unreasonable figure since the yearlings averaged 1.3 fry/stomach on the day that they were sampled (Table 79).

As soon as it was obvious that virtually all the predation was caused by these yearlings, we arranged with the Department of Water Resources for some

C-067088

added river flow. We reasoned that a sudden increase in flow would displace the yearlings and cause them to move downstream. Two flushing flows of three to four days duration were applied to the river. The first flushing flow peaked at about 7,000 cfs on February 1, and the second flow reached about 12,000 cfs on February 9 (Figure 88). After each flow the catch rate and apparent abundance of yearlings remained the same.

Conclusions

1. Serious losses of wild fry to predation will result if yearling king salmon are released from the Feather River Hatchery during the outmigration of wild king salmon fry.
2. Flushing flows of short duration, as applied here, have no noticeable effect upon the distribution and availability of yearlings.
3. Until more is understood about migrant behavior of yearling king salmon, yearlings should be planted downstream in the Feather River in muddy or murky waters and in habitats that will not encourage the yearlings to take up residence.

KING SALMON FINGERLING STRANDING

Fish stranding of some sort is common to all rivers subject to changes in flow. This is especially so in the Feather River when river discharge is changed frequently during the outmigration period of young salmon. These changes in flow create problems in two ways.

First, there are several reaches of the upper river where the river berm is wide, not very high, and has a shallow gradient. When these areas are inundated large ponds, some in excess of 100 yards in length and 30 yards in width and perhaps two to three feet in maximum depth, are formed. In these ponds migrant salmon fingerlings are sometimes trapped.

The seriousness of this problem is still unclear. From February through April 1974 we examined three such pond problem areas. We found that many ponds are formed when water flow falls from 10,000 to 3,500 cfs (Figure 89). However, no salmon were found trapped in these ponds. Undoubtedly this was because the river did not fall to 3,500 cfs until May (Appendix III-7), after the bulk of young salmon had left the upper area.

In other years we have seined these same pond areas to rescue many thousands of small king salmon. Usually this occurred during the February - April period. The extent of this problem, then, depends on the time of the year that water fluctuations occur and the magnitude of such fluctuations.

Nothing we observed supported the thesis that controlled rates of river flow will solve the stranding problems in the large pond areas. Lowered river stages cause fish to move to deep sections of the pools and not back to the river.

The second cause of stranding occurs during any kind of flow reduction whenever small, shallow pools are left behind at the immediate river's edge. These pools may dewater rapidly. The numbers of these pools is not known. The accumulative effect of many such areas might result in a large loss of salmon. However, our studies have never observed large losses.

Conclusions

1. Stranding of king salmon fingerlings takes place in large ponds that form on wide berms adjacent to the river and in small ponds that form at the immediate edge of the river and quickly are dewatered.
2. Most of the fish loss to stranding can be eliminated if, insofar as possible, fluctuations of the river are avoided during the January 1 to June 30 period.
3. The solution to the large-pool stranding problem is to periodically check problem areas and salvage fish when it is necessary. However, this is in most cases not economically feasible.
4. In some instances ditching might be the best answer to the large pond traps.

5. Our study was inadequate to define the extent of stranding of fish in the smaller pools. Until this is done more fully we recommend extending the March 31 end of 500 cfs limitation through June 30, i.e.:

Flow	Control	Time Period
$\leq$ 2,500 cfs	200 cfs in any 24 hour period	Year-round
2,500-3,500	500 cfs in any 24 hour period	Oct. 1 - June 30
$>$ 3,500	None	Year-round

STEELHEAD

Prior to Oroville Dam virtually all the steelhead in the Feather River wned in the areas now inundated or blocked by Lake Oroville. Indeed, during : seven years of our study we neither saw any steelhead spawning in the river r did we sample any steelhead fry that would have resulted from natural spawning.

Because the natural spawning area was lost, a portion of the Feather River iatchery was assigned to maintain the steelhead population. From fish counts made during the interim period of Oroville Project construction an expected run of 2,000 adult steelhead was determined to be the hatchery production goal (Table 82).

Hatchery personnel spent an initial period of three years solving problems inherited by the hatchery from the natural environment. During this time hatchery production was very low (Table 82). Installation of ultra-violet water treatment facilities and careful selection of brood fish have now solved the worst of the hatchery production problems.

From 1968 through 1971 there was no steelhead run of any consequence. This is obvious in both the run totals to the hatchery as well as in the angler catch (Table 82). During this time the angler catch and number of anglers fishing was so low that creel census was a waste of time. Too few anglers were found to report a meaningful census. However, solution of major hatchery problems in 1970 and the resultant releases of quality steelhead migrants provided the excellent runs we had in 1972, 1973 and 1974 (Table 83).

Since hatchery production has increased, the angler catch has risen from a few hundred fish to between one and three thousand fish each year. We have every reason to believe that such runs will continue.